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SALMON ESCAPEMENTS ABOVE ROCK ISLAND DAM, 1954–60

by Robert R. French and Roy J. Wahle

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ABSTRACT

This paper summarizes (1) 7 years' data, 1954-60, on the size and timing of salmon and steelhead runs passing Rocky Reach damsite on the Columbia River above Rock Island Dam and (2) the distribution and abundance of salmon in tributary spawning streams. The majority of spring chinook salmon passing Rock Island continue past Rocky Reach and the Wells damsite to spawn in the Methow River system. Most summer chinook salmon spawn in the Wenatchee River. Sockeye salmon spawn primarily in the Okanogan River in Canada and in the White River in the Wenatchee River system. Length frequency measurements of spawned chinook salmon show that main size groups of probably many age groups are usually present in all tributaries each year. Few unspawned female chinook salmon were observed on the spawning grounds; egg retention was remarkably low among spawned chinook salmon.

INTRODUCTION

Salmon spawning streams between Rock Island and Chief Joseph Dams (located on the Columbia River at river miles 453 and 546, respectively) were surveyed by Bureau of Commercial Fisheries personnel from 1954 through 1960. A major and continuing interest of the surveys was the relative abundance of salmon in the various tributary streams, the spawning times, and specific spawning areas. Results of some of the studies have been published: French and Wahle (1959) reported on the salmon runs in the Wenatchee River system for 1955-57 and (1960) on salmon escapements passing the Rocky Reach damsite in 1956-57.

Interest in the abundance and distribution of these upriver runs of salmon continues because new hydroelectric projects are planned or under construction. In addition to Wells Dam, now being constructed on the Columbia River above Rocky Reach, hydroelectric projects are proposed for the Wenatchee River system, and modifications are planned at existing irrigation dams on the Methow River and at Enloe Dam on the Similkameen River. All projects require provisions for passing anadromous fish populations. Knowledge of sizes, time of passage, and spawning areas of these populations are important for planning project features and operations.

The purpose of this report is to summarize the distribution and abundance of salmon in tributaries above Rock Island Dam for the 7 years, 1954-60, thus providing a record of salmon escapements. Anadromous fish investigated were chinook salmon (Oncorhynchus tshawytscha), sockeye salmon (O. nerka), silver salmon, (O. kisutch), and steelhead (Salmo gairdneri).

SIZE AND TIME OF PASSAGE OF RUNS AT ROCKY REACH

In these investigations we have used the salmon counts at Rock Island Dam and spawning survey counts as the basic data for determining the time of passage and estimating the size of escapements passing Rocky Reach damsite[1] (fig. 1). At the time of these studies, the date of passage of runs at Rock Island Dam, 21 miles downstream from Rocky Reach, was regarded as an approximation of the date the runs would pass Rocky Reach. Subsequent comparisons show a 2- to 3-day travel time for all species from Rock Island Dam to Rocky Reach Dam.[2]

Note.--Robert R. French and Roy J. Wahle, Fishery Biologists (Research), Bureau of Commercial Fisheries Biological Laboratory, Seattle, Wash.

[1] Rocky Reach Dam was completed in 1961.

[2] Richard L. Major and James L. Mighell. A study to measure delay to upstream migrating salmonids at Rocky Reach Dam. Bureau of Commercial Fisheries Biological Laboratory, Seattle, Wash. [Manuscript.]

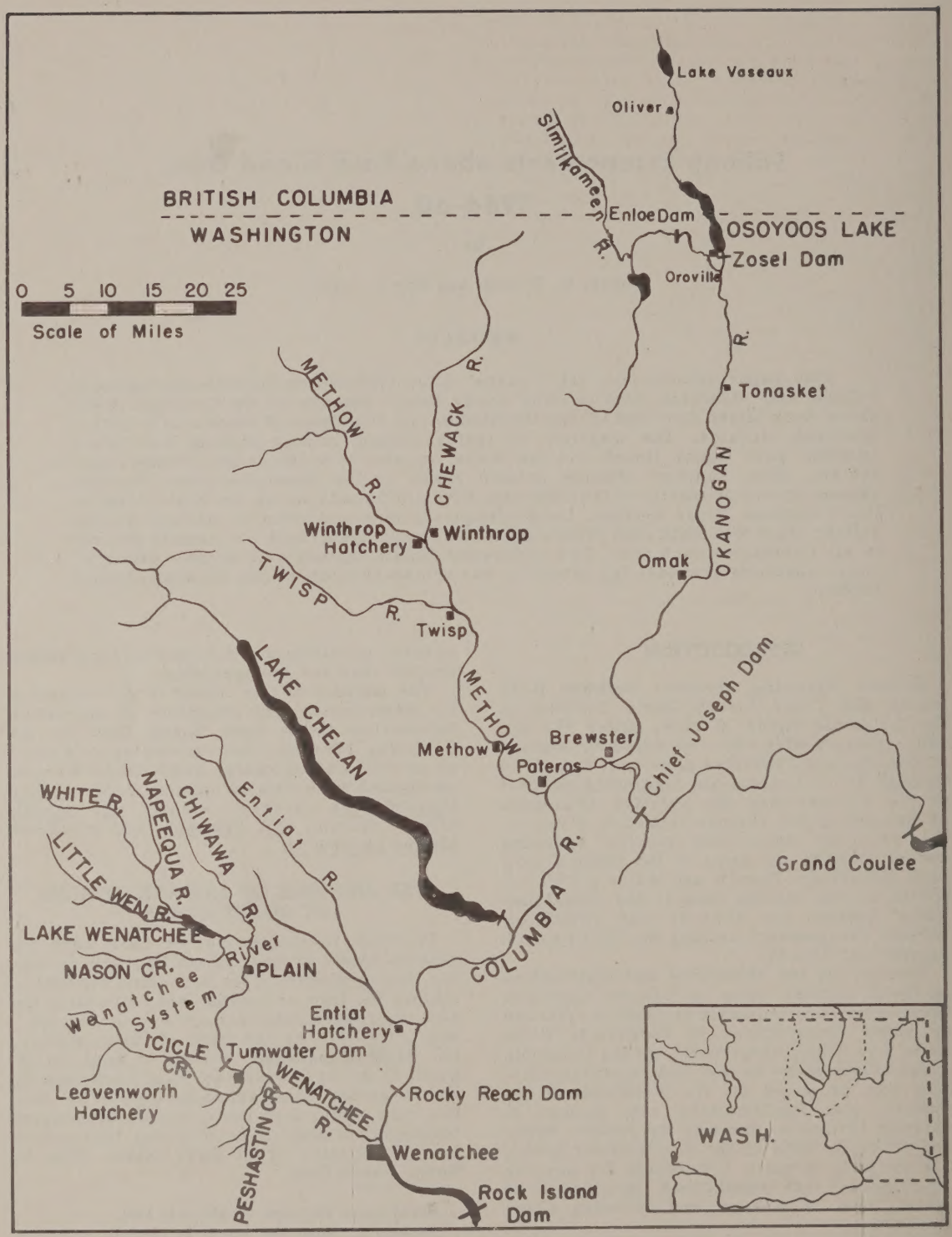

Figure 1.--Columbia River watershed between Rock Island and Grand Coulee Dams.

The size of the chinook salmon escapements passing Rocky Reach damsite was estimated by applying to the Rock Island Dam count the ratio of spawners observed in spawning streams above and below Rocky Reach. First, totals of peak chinook counts for the Wenatchee River system and the river systems above Rocky Reach were compiled, and a ratio calculated of the number of spawners found in the two areas. Then this ratio was applied to the escapements counted at Rock Island Dam to obtain an estimate of the numbers of fish passing Rocky Reach.

To estimate the number of sockeye salmon passing Rocky Reach damsite, we subtracted the number of sockeye passing Tumwater Dam on the Wenatchee River from the Rock Island counts. This procedure was adopted in preference to using stream surveys for obtaining the ratios of sockeye salmon in the areas above and below Rocky Reach.

Chinook Salmon

Chinook salmon runs passing Rock Island Dam show a multimodal distribution according to the time of arrival (fig. 2). These modes are generally associated with the arrival of different seasonal groups (called races) of chinook salmon. At Bonneville Dam (the lowermost dam on the Columbia River) three races are identified by their time of migration--springs, summers, and falls. At Rock Island Dam, Fish and Hanavan (1948) in reporting on the bimodal distribution of the arrival of chinook salmon over the years, separated the spring and summer races on July 9; they did not comment on the existence of a fall run. Meekin (1963) and Pacific Northwest Power Company (1959) identified fall runs at Rock Island. Tagging studies (French and Wahle, 1960) have established that two and possibly the three races at Rock Island pass the dam at different times and that they are separated on the spawning grounds (spring chinook in smaller more remote tributaries, summer chinook in lower main tributaries, and probably fall chinook in the main Columbia River). From aerial surveys we found most spawning in the Columbia River occurred above Rocky Reach damsite, near the confluence of the Okanogan River.

The exact time of separation of the three races varies from year to year. For the purpose of estimating the abundance of the various races at Rock Island, we have designated spring chinook salmon as those arriving by June 18 to July 9 (the exact date depending on the time of division between modes), summer chinook salmon from the end of the spring run to the week ending August 27, and fall chinook salmon after August 27.

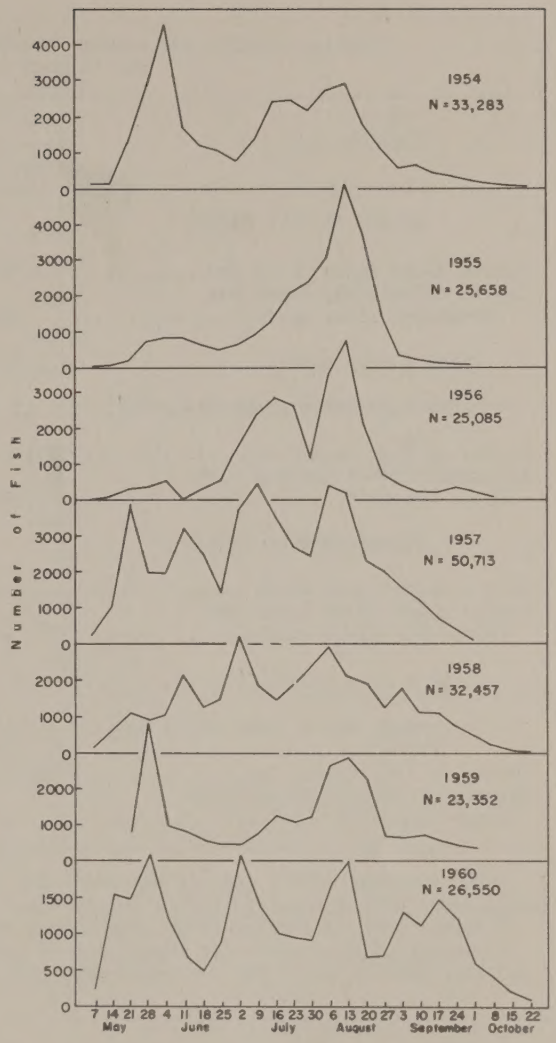

Figure 2.--Weekly chinook salmon counts at Rock Island Dam, 1954-60.

Fall chinook salmon apparently were much more abundant in 1960 than in the previous 6 years (fig. 2). This was surprising in view of the generally decreased escapement of this race in other areas. The effects of the new pool formed behind Priest Rapids Dam (located about 56 miles below Rock Island) may have displaced some fall chinook formerly spawning there and caused them to move upstream to spawn.

More spring chinook salmon (61 to 78 percent of the total passing Rock Island) were calculated to pass to tributaries above Rocky Reach than to the Wenatchee River (table 1), and conversely, more summer chinook salmon were found in the Wenatchee River than in tributaries above Rocky Reach.

Table 1.--Spring and summer chinook salmon counted during stream surveys and at Rock Island Dam, 1954-60

Race and area	Number of fish[1]						
	1954[2]	1955	1956[3]	1957	1958	1959	1960
SPRING CHINOOK SALMON							
Counts above Rocky Reach Dam	1,328	1,019	1,170	3,097	1,503	2,156	1,573
Counts below Rocky Reach Dam (Wenatchee River system)	693	400	334	1,659	636	646	1,019
Total survey count	2,021	1,419	1,504	4,743	2,139	2,802	2,592
Percentage above Rocky Reach Dam	65.7	71.8	77.8	65.3	70.3	77.0	60.7
Counts at Rock Island Dam	13,742	3,944	--	16,631	7,334	7,528	7,774
Estimated number passing Rocky Reach (rounded)	9,028	2,832	--	10,900	5,200	5,800	4,700
SUMMER CHINOOK SALMON							
Counts above Rocky Reach Dam	--	129	539	1,807	1,582	737	838
Counts below Rocky Reach Dam (Wenatchee River system)	--	2,095	2,147	7,409	1,950	1,607	1,683
Total survey count	--	2,224	2,686	9,216	3,532	2,344	2,521
Percentage above Rocky Reach Dam	--	5.8	20.1	19.6	44.8	31.4	33.2
Counts at Rock Island Dam	16,985	21,714	--	29,914	21,610	13,130	12,293
Estimated number passing Rocky Reach (rounded)	--	1,259	--	5,900	9,700	4,100	4,100

[1] The spawning counts include estimates for the Okanogan, Similkameen, and Entiat Rivers when only redds were counted during aerial surveys. Estimates are based on 3.6 fish per redd.
[2] Summer chinook salmon survey counts were not obtained in 1954.
[3] Overlap of runs precluded separation of spring and summer chinook salmon at Rock Island Dam and separate counts of the two races were not obtained.

Table 2.--Sockeye salmon counted at Rock Island and Tumwater Dams, and estimates of fish passing Rocky Reach, 1954-60

Area	Sockeye salmon counts						
	1954	1955	1956	1957	1958	1959	1960
Rock Island Dam	91,234	155,055	92,443	71,261	98,695	72,351	60,341
Tumwater Dam (Wenatchee River system)[1]	26,150	51,820	25,518	28,231	34,000	13,005	30,900
Percentage attributed above Rocky Reach	71.3	66.6	72.4	60.4	65.6	82.0	48.8
Estimated number passing Rocky Reach (rounded)	65,100	103,200	67,000	43,000	64,700	59,000	29,000

[1] No Tumwater Dam counts in 1958 and 1960. Estimates are based on White and Little Wenatchee River weir counts and spawning surveys.

Sockeye Salmon

Counts of sockeye salmon at Rock Island during the period of study varied from approximately 71,000 to 155,000 fish (fig. 3). The timing of the runs was relatively constant with the exception of 1959 when the run was later. We suspect that the temporary fish passage facilities in use at the time at Priest Rapids Dam, then under construction 56 miles below Rock Island Dam, caused a delay because the runs passed Bonneville and McNary Dams (located downstream from Rock Island) at their usual times.

Estimates of sockeye salmon passing Rocky Reach damsite for the period 1954 through 1960 are given in table 2. The year 1960 was the only one for which less than 50 percent of the run was attributed to areas above Rocky Reach damsite.

Steelhead

The count of 6,226 steelhead in 1960 was the highest recorded at Rock Island Dam (fig. 4). From 1954-60 the counts varied from 1,540 to 6,226 steelhead. The counts are of fish passing from May to October only. Periodic counts made during winter have included migrating steelhead, but no abundance estimates have been made.

The spring and fall seasonal steelhead counts are of fish destined to spawn in 2 calendar years. The steelhead spawning population in any one spring is composed of fish that passed Rock Island that spring and the preceding winter and fall. Thus the counts given in figure 4 represent two different groups of spawners, the spring group spawning that same spring and in early summer and the fall group spawning the following spring. By rearranging the counts so as to represent totals for a single year's spawning stock, we have arrived at the following number of spawners:

Year	Number of steelhead
1954-55	4,988
1955-56	3,118
1956-57	1,509
1957-58	4,097
1958-59	3,813
1959-60	4,567
1960-61	4,428

Stocks for the different years were arbitrarily separated on July 2; the counting period is from May 1 to October 1.

No estimates were made of the number of steelhead attributed to areas above Rocky Reach. Sport fishery catches of this species above Rocky Reach are evidence that they

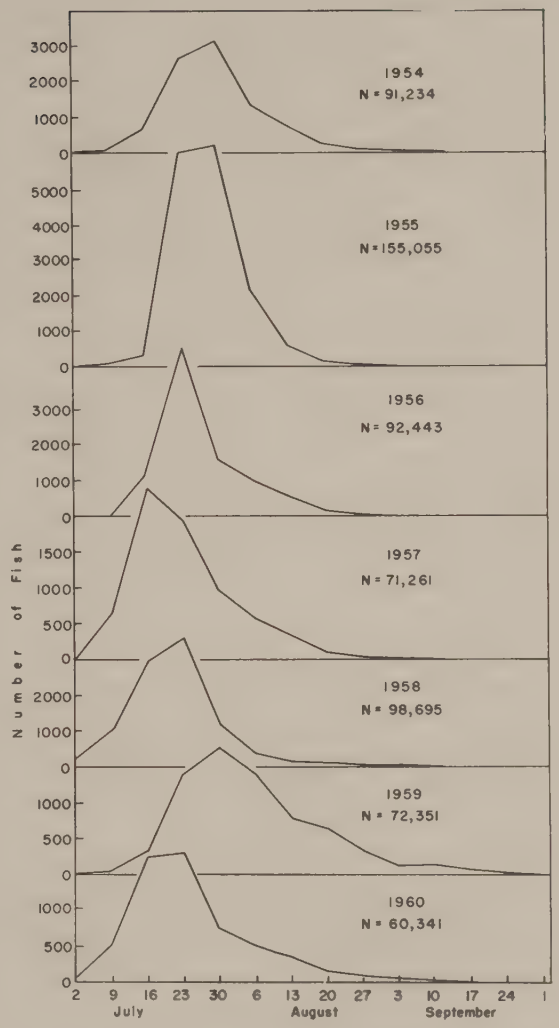

Figure 3.--Weekly sockeye salmon counts at Rock Island Dam, 1954-60.

are found in the area. Because of high runoff and turbid waters during the spring (May and June) we were unable to determine the spawning areas and make estimates of spawners within tributaries.

Silver Salmon

Seasonal counts of silver salmon at Rock Island for the 7 years are not comparable, because of different termination dates in counting (table 3).

No attempts were made to determine the distribution or abundance of this species above Rock Island Dam.

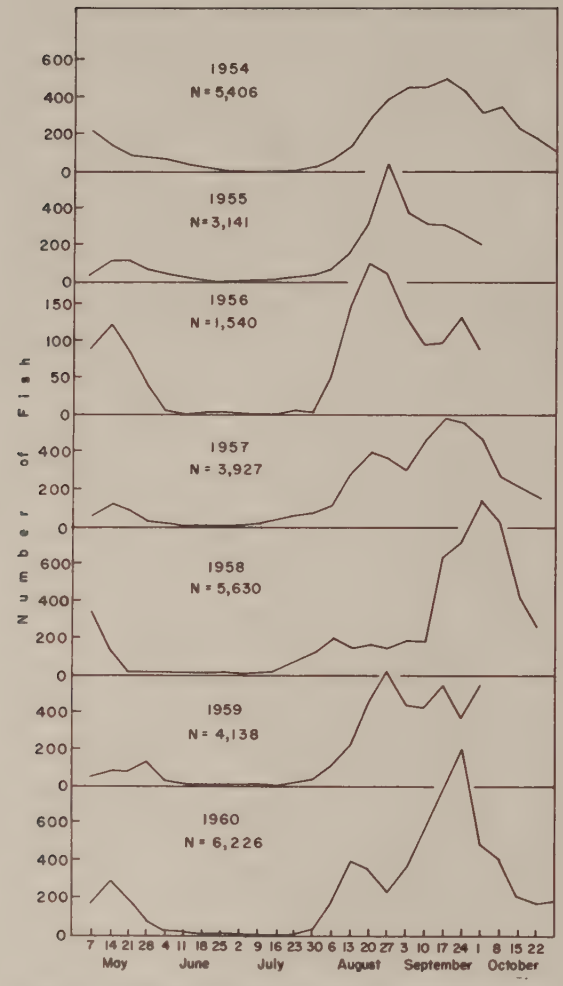

Figure 4.--Weekly steelhead counts at Rock Island Dam, 1954-60.

DISTRIBUTION AND COMPARATIVE ABUNDANCE OF SPAWNERS IN TRIBUTARIES

Spawning streams were surveyed by the same personnel using comparable methods each year. The various streams were surveyed by either walking or floating downstream in a boat. On surveys the numbers of live and dead salmon and number of redds were counted, dead chinook salmon measured for length, and females examined for spawning condition. In 1960 the numbers of eggs retained in the body were determined for all dead female chinook salmon retrieved. In some instances streams were surveyed from an airplane and redds counted.

Table 3.--Silver salmon counted at Rock Island Dam, 1954-60

Year	Date official counting ended	Fish counted		Total
		During official period from May 1	During periodic counts to November 1	
1954	Nov. 26	44	0	44
1955	Oct. 1	41	11	52
1956	Sept. 29	29	65	94
1957	Sept. 28	27	39	66
1958	Oct. 25	75	no counts	75
1959	Sept. 30	118	no counts	118
1960	Oct. 29	94	no counts	94

Official counts: Complete daily counts at the three ladders, May 1 to end of official counts.

Periodic counts: Periodic counts at different hours, after end of official counting period.

Chinook Salmon

The areas within each tributary stream above Rocky Reach Dam utilized by chinook salmon spawners are illustrated in figures 5, 6, and 7, and those of the Wenatchee River system spawning areas in figure 8. The distribution of salmon shown in the figures is a composite of the distribution observed over the 7 years of surveys. The distribution of spawners within individual streams varied only slightly for large and small escapements of various years. Generally, spawning populations chose the same specific areas. Minor changes in specific locations of spawners have been observed within these favored areas. For example, in 1960, in the Methow River, summer chinook salmon were observed in main channel areas where water velocities were greatest. In 1959, when higher flows prevailed during the spawning period, the spawners in these areas were observed closer to shore and away from the high velocities in the main channels of the river.

The peak survey counts (greatest number counted on any one survey) and the time period encompassing the peak of spawning for tributaries above Rocky Reach damsite are given by year in table 4; comparable data for the Wenatchee River system are given in table 5. For purposes of illustrating main spawning areas, the streams are divided into sections. The tables reveal the comparative abundance of spawners within each

Table 4.--Spawning ground peak counts of spring and summer chinook salmon in tributaries above Rocky Reach Dam, 1954-60

[nc=no count]

Race and stream sections	Year							Period of peak of spawning
	1954	1955	1956	1957	1958	1959	1960	
SPRING CHINOOK								
Entiat River:								
Silver Creek Guard Station down 10 miles....	nc	259	149	273	95	198	306	8/23-8/28
Twisp River:								
1.5 miles above Poplar Flats to Mystery Camp	6	45	3	106	83	91	69	8/15-8/20
Mystery Camp to War Creek.....	224	88	94	234	214	266	151	8/15-8/20
War Creek to Buttermilk Trail Bridge.....	223	88	94	348	138	150	80	8/15-8/20
Buttermilk Trail Bridge down 2 miles.....	18	3	0	14	5	11	4	8/15-8/20
Total.....	471	224	191	702	440	518	304	
Chewack River:								
30 Mile Bridge down 1 mile.....	3	4	15	41	20	73	43	8/15-8/20
20 Mile Creek to Falls Creek.....	356	76	170	583	227	340	229	8/25-8/30
Falls Creek to McPhearson Bridge.....	55	127	173	311	89	326	167	8/25-8/30
McPhearson Bridge to Winthrop.....	230	37	46	130	47	140	60	8/25-8/30
Total.....	644	244	404	1,065	[1] 383	879	499	
Methow River:								
Early Winters Creek (up to Cedar Creek).....	nc	nc	41	43	7	9	1	8/15-8/20
Lost River (Bridge up to Eureka Creek).....	nc	nc	nc	182	78	42	18	8/20-8/25
Lost River Bridge to Mazama Bridge.....	[2] 16	30	33	168	103	35	53	8/20-8/25
Mazama Bridge to Weeman Bridge.....	82	46	69	403	224	274	163	8/20-8/25
Weeman Bridge to Winthrop.....	115	58	106	113	84	118	82	8/20-8/25
Winthrop to Twisp.....	[3] 163	158	141	148	89	75	124	9/10-9/15
Twisp to Benson Creek.....	[3] 34	nc	36	nc	nc	8	23	9/10-9/15
Total.....	--	--	426	1,057	585	561	464	
Spring chinook salmon totals.....	--	1,019	1,170	3,097	1,503	2,156	1,573	
SUMMER CHINOOK								
Methow River:								
Winthrop to Twisp.....	nc	nc	nc	nc	153	95	76	10/5-10/10
Twisp to Benson Creek.....	--	nc	nc	421	228	63	95	10/12-10/17
Benson Creek to Carlton.....	--	31	156	249	254	50	188	10/12-10/17
Carlton to Methow.....	--	26	183	604	295	143	192	10/12-10/17
Methow to Columbia River.....	--	0	nc	124	109	51	50	10/12-10/17
Total.....	--	57	339	1,398	1,039	402	601	
Similkameen River:								
Railroad Bridge to Okanogan River.....	13	72	101	189	no vis.	no vis.	90	10/15-10/20
Okanogan River:								
Oroville to Columbia River.....	nc	nc	99	[4] 8	nc	nc	nc	10/15-10/25
SUMMER CHINOOK SALMON REDD COUNTS (Aerial)								
Entiat River:								
Hatchery to Columbia River.....	nc	nc	nc	8	27	12	12	10/15-10/25
Number of fish estimated[5].....	--	--	--	29	97	43	43	
Similkameen River:								
Railroad Bridge to Okanogan River.....	nc	nc	nc	30	30	31	23	10/15-10/25
Number of fish estimated[5].....	--	--	--	--	108	112	--	

Table 4.--Spawning ground peak counts of spring and summer chinook salmon in tributaries above Rocky Reach Dam, 1954-60--Continued

[nc=no count]

Race and stream sections	Year							Period of peak of spawning
	1954	1955	1956	1957	1958	1959	1960	
Okanogan River:	nc	nc						10/15-10/25
Oroville to Tonasket	--	--	1	0	3	3	0	10/15-10/25
Tonasket to Riverside	--	--	13	17	43	21	16	10/15-10/25
Riverside to Omak Bridge	--	--	2	5	7	1	1	10/15-10/25
Omak Bridge to Mallot	--	--	21	24	35	20	8	10/15-10/25
Mallot to Monse	--	--	0	5	6	5	4	10/15-10/25
Monse to Columbia River	--	--	0	2	0	0	0	10/15-10/25
Total	--	--	37	53	94	50	29	
Numbers of fish estimated[5]	--	--	--	191	338	180	104	
Summer chinook salmon totals	--	--	539	1,807	1,582	737	838	

[1] Survey occurred after peak spawning.
[2] Partial area count.
[3] Counts were probably of a mixture of spring and summer chinook as surveys occurred between spawning peak period of the two races.
[4] Survey occurred prior to peak of spawning.
[5] Estimated number of fish based on 3.6 fish per redd.

stream and the relative importance of the various streams.

The Chewack River and the upper Methow River are the most important spring chinook salmon streams above Rocky Reach Dam. In the Wenatchee River system most spring chinook spawners are found in Chiwawa River and Nason Creek with peak abundance varying between the two streams in different years. The spring chinook salmon survey counts in the Entiat River in 1960 were the highest of the 6 years of stream surveys. This occurred in a year when generally fewer spawners were counted in all the other streams.

Summer chinook salmon spawn mainly in the Methow and Wenatchee Rivers; the latter is by far the more important.

The chronology of peak spawning periods for chinook salmon in the upper Columbia River system appeared to be associated with stream temperatures. Spring chinook salmon spawned earliest, mostly in August, when water temperatures in the spawning areas ranged from 48° to 55° F. Within a stream, spring chinook salmon in the upper sections were found to spawn earlier than spring chinooks in the lower sections. Nason Creek (table 5) is a good example. Here, at the time spring chinook salmon were spawning in the upper sections in water temperatures of around 50°-55° F., those in the lower sections were congregated in pools where water temperatures were around 60° F. Later, as the water temperature in the lower sections dropped to the range of 50°-55°, these fish moved onto the spawning riffles. Summer chinook salmon spawned later in the season (October) when water temperatures in these spawning areas had fallen to 50°-55° F.

Length frequency.--Lengths (mideye to end of hypural plate) of dead spawned fish were taken to determine if age classes could be differentiated by modal groups (tables 6 and 7). Ages could not be read from scales because of scale absorption on the spawned fish. Although modal groups are evident, more so among spring than summers, there is too much overlap of lengths to distinguish age classes without corroborating evidence, except possibly for jack chinook salmon. Jack chinook salmon are precocious males, returning from the ocean in the year following their seaward migration, with lengths (mideye-hypural plate) ranging from approximately 300 mm. to 450 mm. for spring chinook salmon and from approximately 280 mm. to 400 mm. for summer chinook salmon.

Although these data do not show differentiation of all age groups, they illustrate that main size groups, consisting of probably several age groups, are usually present in all tributaries each year. One exception was found in the Chewack River for 1957 where large chinook salmon of both sexes were noticeably absent. Summer chinook salmon

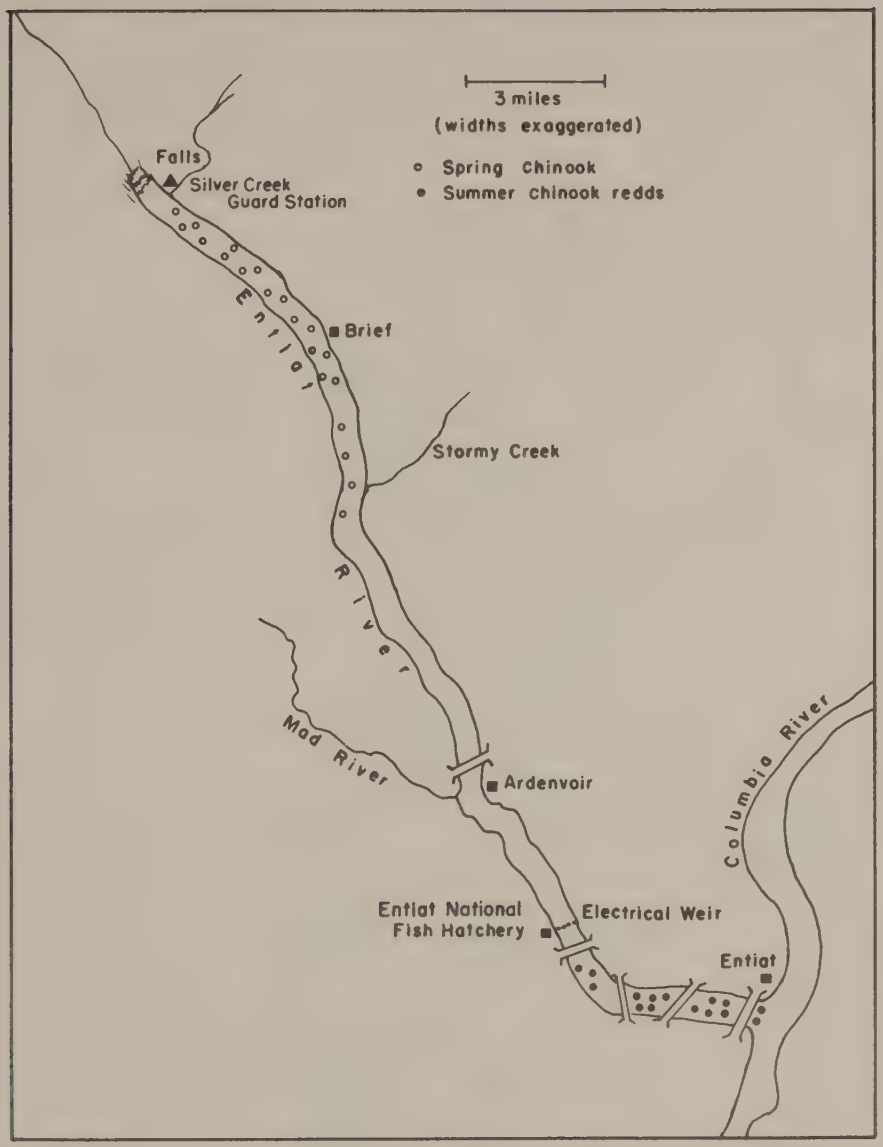

Figure 5.--Areas of spawning in the Entiat River.

show a substantially greater size range than the spring chinook.

Spawning condition and egg retention.--Dead chinook female salmon were examined during 1957-60 surveys to determine if they had spawned (table 8). The average figure of 1.7 percent unspawned females was comparable to the average of 3 percent found for fall chinook salmon in the Snake River.[3]

[3] Monte Richards. Snake River fall chinook spawning ground survey, 1958. State of Idaho Department of Game, 13 p. [Typewritten.]

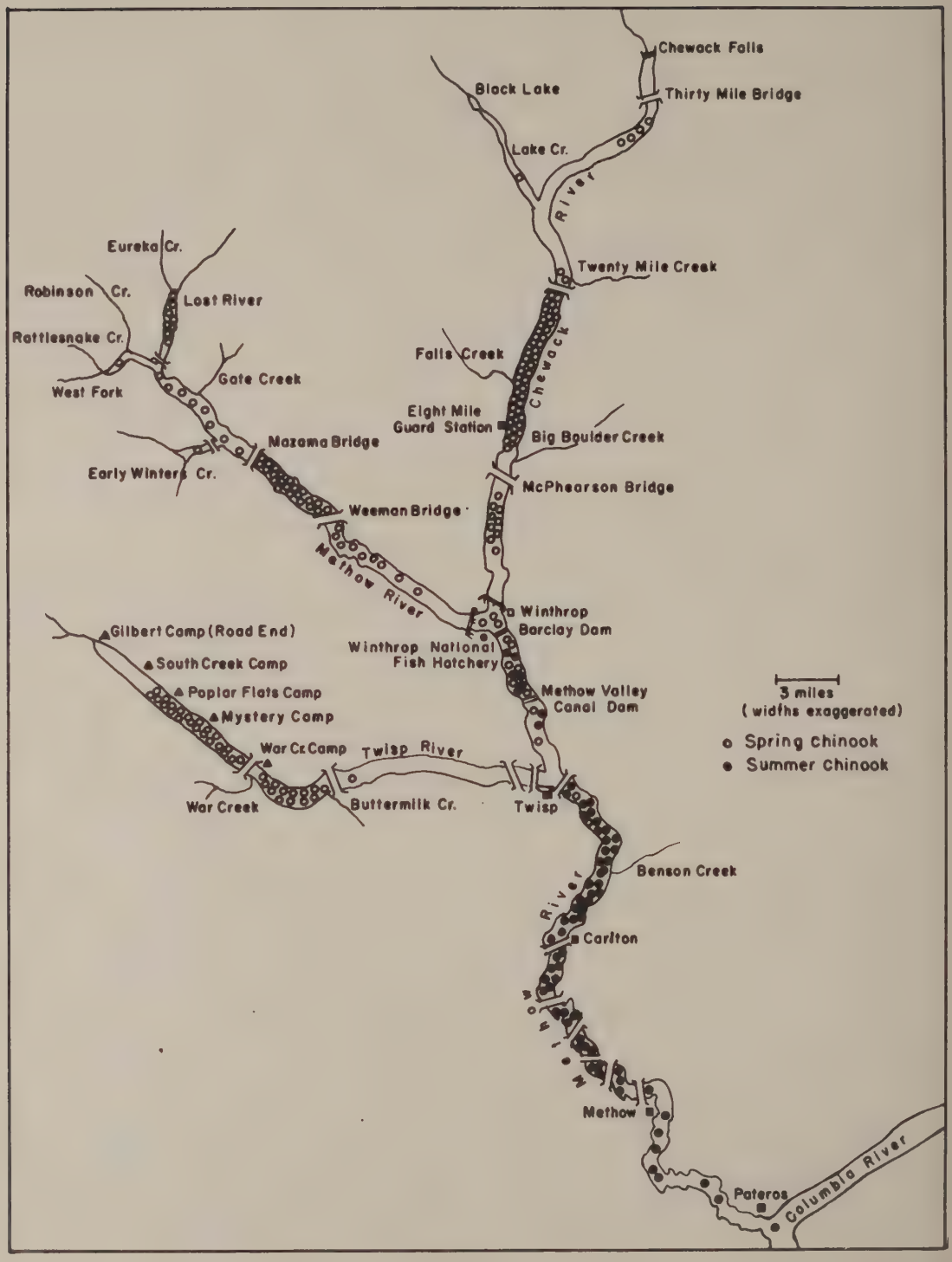

Figure 6.--Areas of spawning in the Methow River system.

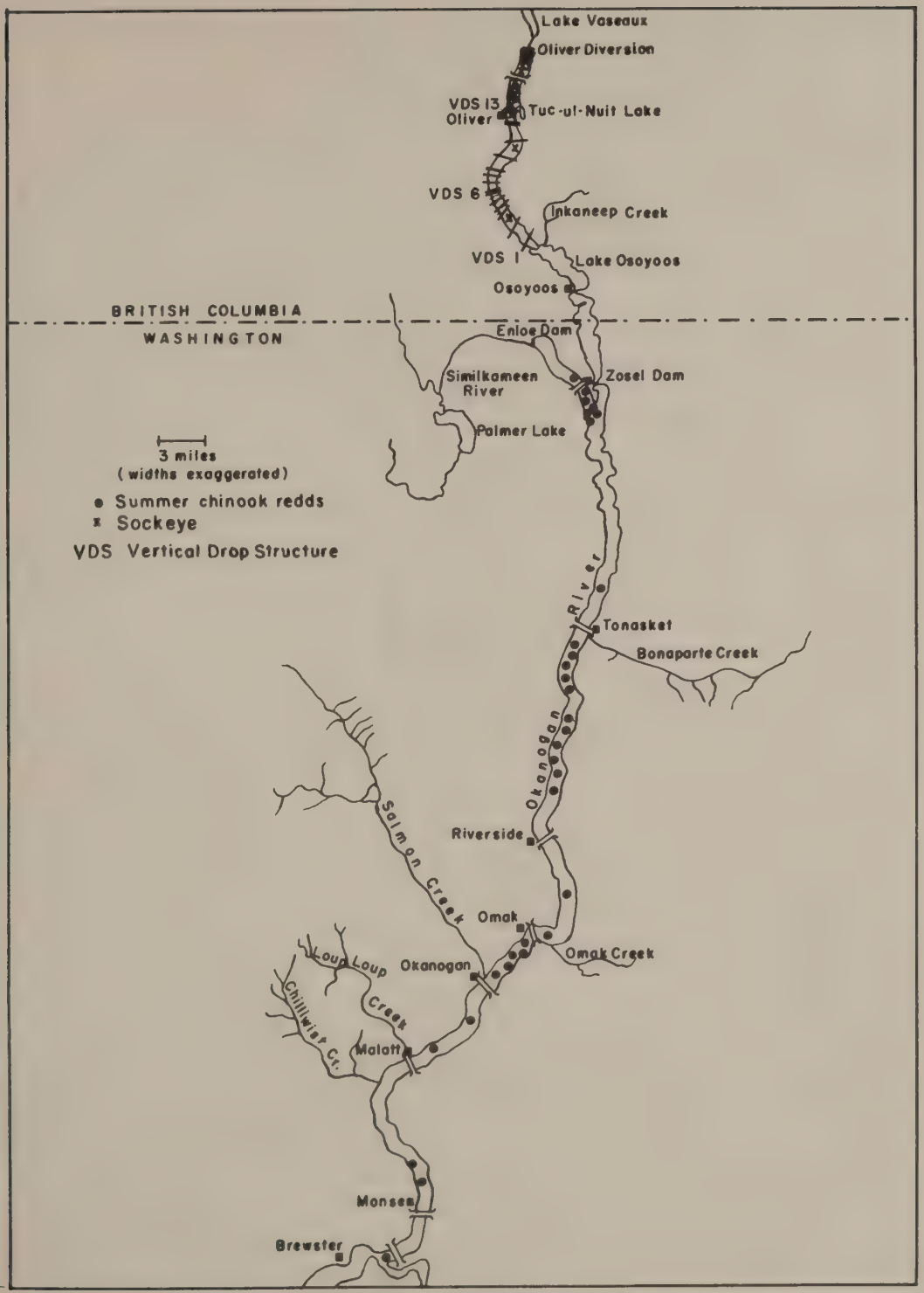

Figure 7.--Areas of spawning in the Okanogan and Similkameen Rivers.

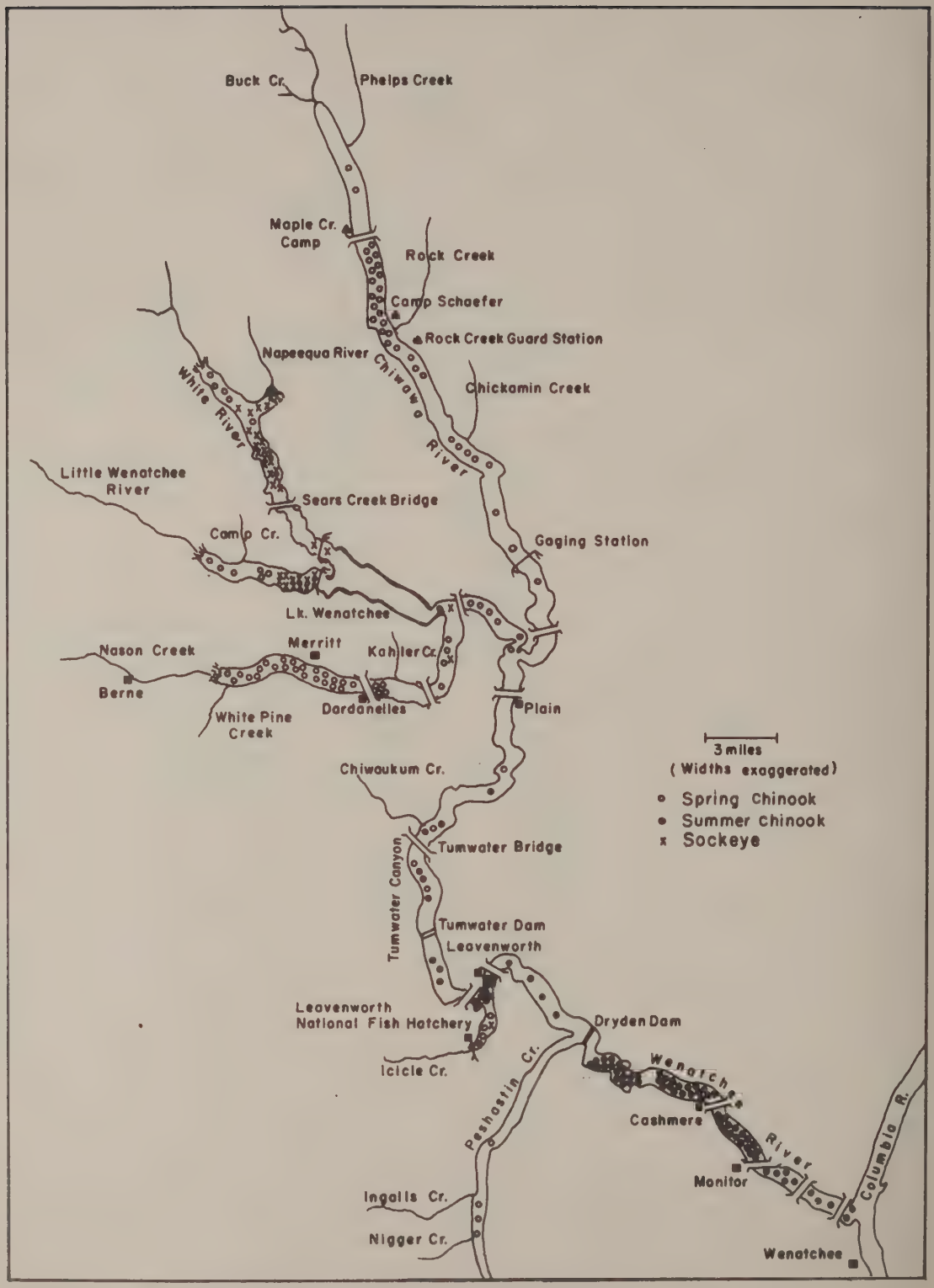

Figure 8.--Areas of spawning in the Wenatchee River system.

Table 5.--Spawning ground peak counts of spring and summer chinook salmon in the Wenatchee River system, 1954-60

[nc= no count. nv = no visibility]

Race and stream sections	Year							Period of peak of spawning
	1954	1955	1956	1957	1958	1959	1960	
SPRING CHINOOK								
Chiwawa River:								
Phelps Creek to Maple Creek Camp	6	13	2	26	8	22	35	8/23-8/28
Maple Creek Camp to Schaefer Camp	43	35	37	125	63	27	81	8/23-8/28
Schaefer Camp to Rock Creek Guard Station	21	35	66	143	82	42	105	8/23-8/28
Rock Creek Guard Station to gauging station	30	27	51	136	91	110	198	8/23-8/28
Total	100	110	156	430	244	201	419	
Icicle Creek:								
Hatchery to Wenatchee River	33	50	33	84	44	127	54	9/5-9/10
Little Wenatchee River:								
Falls to Swamp area	nc	nc	nc	60	26	20	8	8/18-8/23
Swamp area to Lake Wenatchee	nc	nc	16	15	10	15	52	8/31-9/4
Total	--	--	16	75	36	35	60	
Nason Creek:								
Falls to Railroad Bridge	5	3	2	180	86	73	70	8/15-8/20
Railroad Bridge to 1/2 mile below highway bridge	149	61	61	599	81	66	145	8/20-8/25
Coles Corner to Wenatchee River	28	46	9	62	11	62	56	9/8-9/13
Total	181	110	72	841	178	201	271	
Peshastin Creek:								
Nigger Creek to Ingalls Creek	nc	6	15	41	nv	nv	3	8/15-8/20
White River:								
Grasshopper Meadow to Napeequa River	10	5	12	48	34	12	51	8/30-9/4
Napeequa River down 1 mile	nc	0	nc	6	nv	1	2	8/30-9/4
Total	10	5	12	54	34	13	53	
Wenatchee River:								
Lake Wenatchee to Plain	296	74	21	134	100	69	141	9/15-9/25
Plain to Tumwater Canyon Bridge	73	45	9	13	nc	nc	nc	9/15-9/25
Bridge to Tumwater Dam	nc	nc	nc	nc	nc	nc	18	9/15-9/25
Total	369	119	30	147	100	69	159	
Spring chinook salmon totals	693	400	334	1,672	636	646	1,019	
SUMMER CHINOOK								
Wenatchee River:								
Lake Wenatchee to Plain	nc	nc	nc	16	1	nv	0	10/10-10/15
Plain to Tumwater Canyon Bridge	nc	nc	nc	111	2	nv	32	10/10-10/15
Bridge to Tumwater Dam	nc	nc	nc	10	47	0	25	10/10-10/15
Tumwater Dam to mouth of canyon	nc	102	290	180	132	9	82	10/15-10/20
West Leavenworth Bridge to East Leavenworth Bridge	210	850	569	1,090	394	448	428	10/15-10/20
East Leavenworth Bridge to Dryden Dam	nc	nc	nc	223	77	9	52	10/15-10/20
Dryden Dam to East Cashmere Bridge	233	559	1,040	2,479	459	647	718	10/15-10/20
East Cashmere Bridge to Monitor Bridge	145	362	65	1,770	527	312	78	10/15-10/20
Monitor Bridge to Columbia River	60	222	183	1,530	311	182	268	10/15-10/20
Summer chinook salmon totals	648	2,095	2,147	7,409	1,950	1,607	1,683	

Table 6.--Length frequency distribution of spring chinook salmon from spawning streams above Rock Island Dam, 1957-60. Mideye to hypural plate measurements, in 10-mm. groupings

Female

Length	1957					1958					1959					1960					Total
	Entiat	Twisp	Chewack	Methow	Wenatchee R. system	Entiat	Twisp	Chewack	Methow	Wenatchee R. system	Entiat	Twisp	Chewack	Methow	Wenatchee R. system	Entiat	Twisp	Chewack	Methow	Wenatchee R. system	
Millimeters																					
510.....	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	1
520.....	--	--	--	--	--	--	1	--	--	--	--	--	1	--	--	--	--	--	--	--	2
530.....	--	--	--	--	--	--	--	1	--	--	--	--	--	1	--	--	--	--	--	--	2
540.....	--	--	--	--	--	--	--	4	--	1	--	--	--	--	--	--	--	--	--	1	6
550.....	--	--	--	--	--	1	--	6	2	2	--	--	--	1	1	--	--	--	1	--	14
560.....	--	--	1	--	2	1	2	3	2	1	--	--	1	--	3	--	--	--	1	2	19
570.....	2	--	1	--	--	--	1	4	2	--	--	--	2	--	1	--	1	1	1	2	18
580.....	1	--	--	1	--	--	1	8	3	1	1	1	3	--	--	--	1	--	--	1	22
590.....	1	--	1	1	2	2	2	4	4	--	--	1	3	2	2	--	--	--	2	--	27
600.....	1	--	6	2	4	--	4	6	3	4	1	3	7	1	--	--	--	--	--	4	46
610.....	--	--	1	5	4	1	4	2	1	3	2	1	4	2	2	1	--	--	2	--	35
620.....	1	3	2	3	7	--	1	3	1	2	3	1	1	1	1	--	1	--	--	1	32
630.....	--	3	5	3	3	1	1	1	1	3	1	3	3	3	2	1	3	1	1	2	41
640.....	1	5	2	4	4	--	--	3	2	3	--	3	2	4	--	--	--	--	6	2	41
650.....	--	2	--	5	2	--	3	--	2	1	--	5	--	4	--	--	1	--	3	--	28
660.....	--	6	1	2	1	1	1	2	1	--	1	1	2	4	--	--	--	1	4	--	28
670.....	--	3	--	1	1	--	--	2	2	3	--	2	2	--	1	--	--	--	5	--	22
680.....	1	1	1	1	2	--	1	2	3	4	--	1	2	1	1	1	--	--	3	4	29
690.....	--	--	1	--	1	--	--	4	2	7	--	1	1	3	2	--	--	--	6	1	29
700.....	--	2	--	1	1	--	2	3	2	4	--	1	2	2	--	--	1	--	3	1	25
710.....	1	--	--	2	1	--	1	3	3	3	--	2	2	5	--	--	1	--	--	1	25
720.....	2	1	--	4	1	--	3	2	5	1	1	6	3	1	--	--	1	--	3	--	34
730.....	3	1	--	--	1	--	3	1	2	5	--	1	--	3	--	--	1	--	--	--	21
740.....	2	3	--	1	3	--	2	1	1	1	1	4	--	3	1	--	--	--	1	--	24
750.....	--	2	--	3	--	--	4	1	1	--	--	2	1	1	--	--	--	--	1	--	16
760.....	1	5	--	1	--	--	3	--	--	--	--	--	--	2	--	--	2	--	--	--	14
770.....	--	--	--	2	1	--	2	--	2	1	--	1	--	3	--	--	--	--	--	--	12
780.....	1	3	--	--	--	--	1	--	1	--	--	3	--	--	--	--	1	--	--	--	10
790.....	--	1	--	1	1	--	--	--	--	--	--	--	--	--	--	--	1	--	1	--	5
800.....	--	2	--	--	--	--	--	--	--	--	--	2	--	1	1	--	--	--	--	1	7
810.....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
820.....	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2
Total.....	18	45	22	43	42	7	43	67	48	50	11	45	42	48	18	3	15	3	44	23	637

Male

Under 300...	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
300.....	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
310.....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
320.....	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	1
330.....	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
340.....	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
350.....	--	4	--	--	--	--	--	2	--	--	--	--	--	--	--	--	--	--	--	--	6
360.....	--	4	1	1	--	--	--	2	--	--	--	--	--	--	--	--	--	--	--	--	8
370.....	--	3	--	--	--	--	--	1	--	--	1	2	--	--	--	--	--	--	--	1	8
380.....	--	7	1	--	1	--	--	3	--	--	--	1	--	--	1	--	--	--	--	--	14
390.....	1	2	--	1	--	--	1	3	--	--	--	--	--	--	--	--	--	--	--	--	8
400.....	1	2	--	1	--	--	--	3	--	2	--	--	--	1	2	--	--	--	1	--	13

Table 6.--Length frequency distribution of spring chinook salmon from spawning streams above Rock Island Dam, 1957-60. Mideye to hypural plate measurements, in 10-mm. groupings --Continued

Male--Continued

Length	1957					1958					1959					1960					Total
	Entiat	Twisp	Chewack	Methow	Wenatchee R. system	Entiat	Twisp	Chewack	Methow	Wenatchee R. system	Entiat	Twisp	Chewack	Methow	Wenatchee R. system	Entiat	Twisp	Chewack	Methow	Wenatchee R. system	
Millimeters																					
410	--	3	--	--	1	--	1	--	--	1	--	--	--	--	1	--	--	--	--	--	7
420	--	2	1	--	--	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	5
430	--	2	--	--	--	--	--	--	--	1	--	--	--	1	1	--	--	--	--	--	5
440	--	1	1	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3
450	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
460	--	--	--	1	--	--	--	3	--	1	--	--	--	--	1	--	--	--	--	--	6
470	--	1	--	--	--	--	--	1	--	--	--	1	1	--	--	--	--	--	--	--	4
480	--	1	--	--	--	--	--	2	--	--	--	--	1	--	--	--	--	--	--	--	4
490	--	--	--	--	--	--	--	--	--	2	--	1	--	--	--	--	--	--	1	--	4
500	--	1	1	1	1	--	--	2	--	1	--	--	--	--	--	--	--	--	--	--	7
510	--	2	--	--	1	--	1	1	--	--	--	--	1	1	--	--	--	--	--	--	7
520	--	--	1	--	--	--	3	2	--	5	--	2	--	--	1	--	--	--	--	--	14
530	--	2	3	--	1	--	4	3	--	--	--	2	1	--	--	--	--	--	--	--	16
540	--	4	3	--	3	--	--	1	--	3	--	1	1	1	--	--	1	1	--	--	19
550	--	7	--	--	1	1	1	1	1	1	2	2	--	2	--	--	--	--	2	--	21
560	2	5	1	--	2	--	2	2	--	2	--	1	1	--	--	--	--	--	--	1	19
570	--	7	2	2	2	--	2	1	--	--	--	1	2	--	--	--	1	--	--	1	21
580	--	7	--	3	4	--	--	1	--	--	--	2	--	1	1	--	--	--	1	2	22
590	--	7	2	2	1	--	1	1	1	--	--	1	--	2	1	--	--	--	1	--	20
600	1	4	2	--	2	1	1	4	1	--	3	2	2	--	--	1	1	--	--	1	26
610	--	1	3	--	2	--	--	2	1	2	--	--	--	1	--	--	--	--	2	1	15
620	1	3	2	1	--	--	--	1	--	2	--	1	--	--	--	--	--	--	3	--	14
630	--	1	2	--	1	--	1	--	1	--	1	--	--	--	--	--	--	--	1	--	8
640	--	6	1	--	2	--	1	--	--	3	--	--	1	--	1	--	1	--	2	1	19
650	--	1	1	1	1	--	2	--	1	--	1	--	--	--	1	--	--	--	3	--	12
660	--	--	--	2	1	--	--	1	--	1	--	--	--	--	1	--	--	--	1	--	7
670	--	--	1	2	--	--	--	--	--	--	1	--	--	--	1	--	--	--	--	--	5
680	--	--	1	2	1	--	--	--	--	--	--	--	--	1	--	--	--	--	1	1	7
690	--	--	--	1	1	--	--	--	--	1	--	--	--	--	--	--	--	--	1	--	4
700	--	--	--	--	--	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	2
710	--	--	--	1	--	--	1	1	2	--	--	--	--	--	--	--	--	--	--	--	5
720	--	--	--	1	--	1	--	1	--	1	--	--	--	1	--	--	--	--	--	--	5
730	--	--	--	--	1	--	--	2	--	2	--	--	--	1	--	--	--	--	--	--	6
740	--	--	--	--	--	--	--	--	1	1	--	--	2	--	--	--	--	--	--	--	4
750	--	--	--	--	--	--	1	--	--	1	--	--	1	--	1	--	--	--	--	--	4
760	--	--	--	--	1	--	1	--	1	--	--	--	--	--	--	--	--	--	--	--	3
770	--	--	--	1	--	--	1	1	--	--	--	1	--	--	--	--	--	--	--	--	4
780	--	--	--	--	--	--	--	--	1	--	1	1	--	2	1	--	--	--	--	--	6
790	--	--	--	--	--	--	--	--	1	1	--	--	--	--	--	--	1	--	--	--	3
800	--	--	--	1	--	--	--	--	1	1	--	--	--	1	--	--	--	--	--	--	4
810	--	--	--	--	--	--	--	--	--	1	--	--	1	--	--	--	--	--	--	--	2
820	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	1
830	--	1	--	--	--	--	--	--	--	--	--	2	--	--	--	--	--	--	--	--	3
840	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
850	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
860	--	--	--	--	--	--	--	--	--	--	--	1	--	1	--	--	--	--	--	--	2
870	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
880	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
Total	6	94	30	26	32	4	28	50	13	36	10	25	15	18	15	1	5	1	20	9	438

Table 7.--Length frequency distribution of summer chinook salmon from spawning streams above Rock Island Dam, 1957-60. Mideye to hypural plate measurements, in 10-m. groupings

Length	1957	1958	1959	1960	Total
Millimeters	Female				
540	--	1	--	--	1
550	--	--	--	--	--
560	--	--	--	--	--
570	--	--	--	--	--
580	--	--	--	--	--
590	--	--	--	--	--
600	1	--	--	--	1
610	1	--	--	--	1
620	1	--	--	--	1
630	--	--	--	--	--
640	--	--	--	--	--
650	2	2	--	1	5
660	--	--	--	1	1
670	--	3	--	2	5
680	--	1	--	--	1
690	3	3	--	1	7
700	4	7	--	2	13
710	2	7	--	--	9
720	5	5	2	--	12
730	3	4	--	--	7
740	6	4	--	1	11
750	10	3	--	1	14
760	5	7	--	1	13
770	10	7	1	2	20
780	10	6	1	--	17
790	6	1	2	--	9
800	10	10	2	--	22
810	11	5	2	--	18
820	12	2	1	1	16
830	3	5	--	1	9
840	10	2	--	--	12
850	9	3	--	1	13
860	5	3	1	--	9
870	6	2	--	1	9
880	2	1	--	--	3
890	4	--	--	--	4
900	1	--	--	--	1
910	1	--	--	--	1
920	--	--	--	--	--
Total	143	94	12	16	265
	Male				
280	1	--	--	--	1
290	--	--	--	--	--
300	1	1	--	--	2
310	2	1	--	--	3
320	1	1	--	--	2
330	2	1	--	--	3
340	2	3	--	1	6
350	--	--	--	--	--
360	1	1	--	--	2
370	--	1	--	--	1
380	1	--	--	--	1

Length	1957	1958	1959	1960	Total
Millimeters	Male--Continued				
390	1	--	1	--	2
400	--	--	--	--	--
410	3	--	--	--	3
420	3	--	--	--	3
430	4	1	--	--	5
440	1	--	--	--	1
450	2	1	--	--	3
460	3	1	--	--	4
470	6	2	2	--	10
480	6	2	--	1	9
490	2	1	1	--	4
500	4	--	1	--	5
510	3	--	--	--	3
520	4	2	1	--	7
530	2	1	--	--	3
540	3	2	1	--	6
550	6	1	--	--	7
560	3	2	1	--	6
570	3	2	--	1	6
580	3	5	1	--	9
590	2	4	--	--	6
600	2	3	--	1	6
610	4	5	--	--	9
620	4	1	--	--	5
630	1	1	--	--	2
640	2	2	--	--	4
650	6	1	--	1	8
660	1	6	--	--	7
670	5	1	1	--	7
680	3	5	--	--	8
690	3	2	--	--	5
700	2	2	--	--	4
710	2	4	--	--	6
720	5	--	--	--	5
730	4	2	--	--	6
740	2	2	--	--	4
750	2	--	1	2	5
760	2	3	--	--	5
770	--	1	--	--	1
780	--	--	--	1	1
790	2	--	--	--	2
800	2	1	--	--	3
810	3	1	2	--	6
820	2	1	--	--	3
830	2	1	--	--	3
840	2	--	2	--	4
850	5	1	--	--	6
860	2	1	--	--	3
870	2	--	1	1	4
880	3	--	1	--	4
890	3	2	--	--	5
900	3	--	1	--	4
910	2	1	--	--	3
920	1	--	1	--	2
Total	159	86	19	9	273

GPO 886-125

Table 8.--Unspawned female spring and summer chinook salmon in streams above Rock Island Dam, 1957-60

Year	Females examined	Unspawned	
	Number	Number	Percent
1957.....	313	7	2.2
1958.....	309	5	1.6
1959.....	176	1	0.6
1960.....	100	2	2.0
Total.....	898	15	1.7

During 1960, a count was made of the number of eggs retained in those fish that had spawned (table 9). Egg retention was remarkably low. Very little difference was noticed in comparing egg retention of spring and summer chinook salmon.

Sockeye Salmon

The two most important runs of sockeye salmon remaining in the Columbia River system spawn in the Wenatchee and Okanogan River systems (figs. 7 and 8). In the Okanogan River, most spawning occurred above the town of Oliver, British Columbia, although substantial spawning occurred near and below the town. In 1957-58, the construction of 13 vertical-drop structures by the Canadian Government as a flood control project resulted in spawning area changes. As a result, nearly all of the spawning has been concentrated above the 13th drop structure with only a scattering of spawners observed between the structures. Aerial surveys of the river in 1959 showed some spawning between all structures but one; in 1960 spawning redds were observed in only one section.

In the Wenatchee River system, most sockeye salmon spawn in the White River above Lake Wenatchee; the Little Wenatchee River is a second major spawning area. Spawners have been noted for some years in the Wenatchee River at the outlet of the lake and in the vicinity of the town of Leavenworth. A few have been observed spawning in Nason Creek.

Scattered sockeye salmon spawners are found in the Entiat, Methow, and Similkameen Rivers; some are found also at the Entiat and Winthrop National Fish Hatcheries.

Table 9.--Egg retention in spawned female spring and summer chinook salmon in streams above Rock Island Dam in 1960[1]

Eggs retained	Fish examined
Number	Number
0.....	63
1-10.....	24
11-100.....	5
101-200.....	3
201-400.....	2

[1] In addition to the 97 spawned fish, three unspawned females were observed, one of which probably died from spear wounds noted on the carcass.

SUMMARY

Important runs of chinook salmon, sockeye salmon, and steelhead pass Rock Island Dam on the Columbia River bound for spawning areas in main tributaries between Rock Island and Chief Joseph Dams.

Most spring chinook salmon passing Rock Island Dam in 1954 to 1960 continued past Rocky Reach damsite and the Wells damsite to spawn in the Methow River system. Most summer chinook salmon passing Rock Island spawned in the Wenatchee River; fall chinook salmon passing Rock Island probably spawned in the main Columbia River, mainly above Rocky Reach damsite. Sockeye salmon passing Rock Island Dam spawned in both the Wenatchee and Okanogan River systems. The majority of sockeye salmon counted at Rock Island was estimated to have passed Rocky Reach damsite bound for the Okanogan River spawning areas in 6 of the 7 years of investigations.

Most steelhead arrived at the upper Columbia River areas during the fall. Silver salmon were comparatively few in number.

Spawning surveys showed the Chewack River in the headwaters of the Methow River system to be the most important spring chinook salmon stream. The Wenatchee River is the most important summer chinook salmon stream.

Length frequency distribution of chinook salmon measured on spawning grounds indicates a wide length distribution of all age groups in all tributaries each year. Large spring chinook salmon of both sexes were noticeably absent from the Chewack River samples obtained in 1957.

Few unspawned female chinook salmon were observed on the spawning grounds; of 898 females examined, only 15 (1.7 percent) were

unspawned. Egg retention was remarkably low among spawned female chinook salmon; most females examined in 1960 had completely spawned.

Sockeye salmon spawn primarily upriver from the town of Oliver, British Columbia, in the Okanogan River and in the White River in the Wenatchee River system.

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